

NDIA 46th Annual Fuze Conference
Ordnance Fuzing/Safety & Arming
Programs Overview



John Hendershot

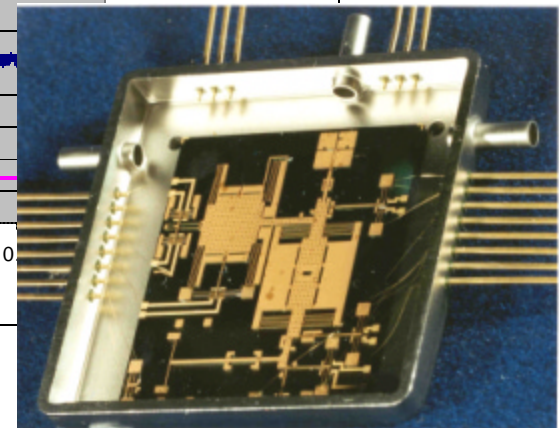
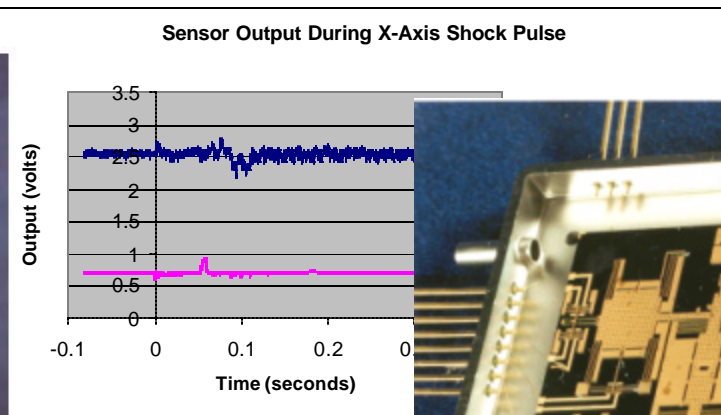
(Code 4420: Phone 301-744-1934 or e-mail hendershotje@ih.navy.mil)

Fuze Safe & Arm Branch Manager

OUTLINE

FY01-02

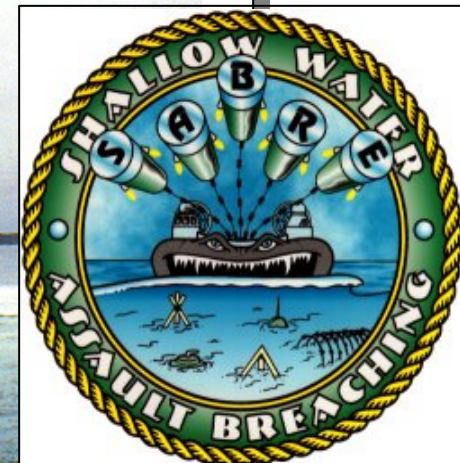
- ◆ **Development Programs**
- ◆ **Technology Demonstrations**
- ◆ **Technology Programs & Spin-offs**
- ◆ **Technology & Infrastructure Investments**





SABRE MOD 2 Fuze/S&A Development

Fuze/S&A for Shallow-water Assault Breaching (SABRE) System





SABRE MOD 2 Fuze/S&A Development

FY01

- ◆ **Contractor Development - Contract Awarded (4/01) to Ensign Bickford Aerospace & Defense**
 - ◆ **Fire-and-Forget Fuze/Safety and Arming System**
 - ◆ **Requires .982 Reliability**
 - ◆ **Sterilize within 60 sec after launch**
 - ◆ **Sense in-water environment as condition for arming**
- ◆ **Conducted lab & flight tests of prototypes**
- ◆ **SABRE & DET Development Canceled (9/01)**

NSFS ERGM M80 PIP (Product Improvement Program)



Extended Range Guided Munition (ERGM)



MISSION:

Naval Surface Fire Support of Ground Troops

ERGM WARHEAD STATUS:

- ◆ M80 Submunition Payload Put on Hold in Favor of Unitary Payload - 28 January 2002
- ◆ M80 PIP EX 433 Proximity Fuze Design Goals Met
 - Technical Data Package Available ~ 30 September 2002



NSFS ERGM M80 PIP

EX 433 Proximity Fuze System Development Team



Fuze/Battery Expertise Drawn From:

Army / Navy Labs and Industry



Hittite Microwave Corp

Integrated Circuit Systems

Amkor Technology

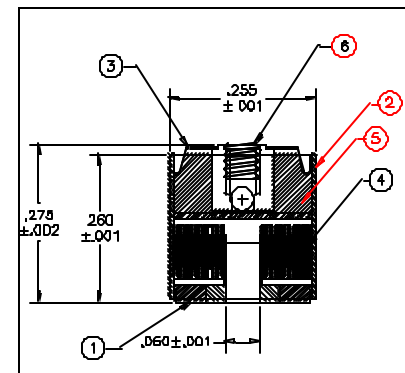


NSFS ERGM M80 PIP

EX 433 Mod 0 Proximity Fuze

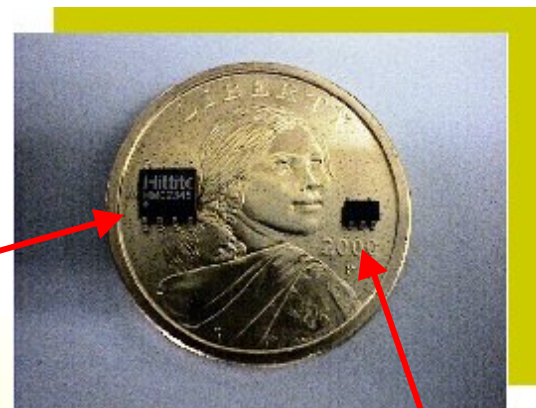
PROGRAM ACHIEVEMENTS:

- ◆ **Successful New Reserve Battery Development**
 - **Gun Setback Activated**



- ◆ **Successful Ultra Low Power Miniaturization of M734A1 Proximity RF Transceiver**

M734A1 Transceiver



EX 433 MMIC



NSFS ERGM M80 PIP

EX 433 Mod 0 Proximity Fuze

PROGRAM ACHIEVEMENTS: (cont'd)

- ◆ Developed Functional Narrow Band Monopole Antenna

Antenna Exposed



Antenna Embedded

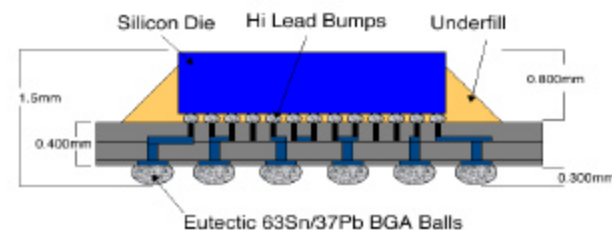
- ◆ Successfully Developed Low Power Signal Processor IC

- Chip Scale Packaging (CSP)



Flip Chip CSP

Ceramic *fc*CSP Diagram



- Two layer Ceramic Substrate
- Dielectric on Bottom Layer for BGA Pads



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NSFS-EX433-0000



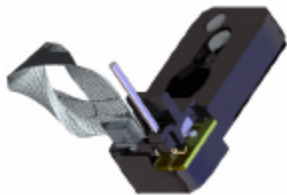
NSFS ERGM M80 PIP

EX 433 Mod 0 Proximity Fuze

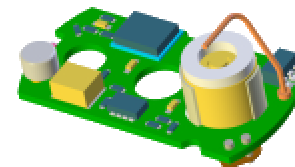
PROGRAM ACHIEVEMENTS: (cont'd)

- ◆ **One-for-One Slide Assembly Goal of an Add-On Proximity Fuze Achieved and Produced**

Replaced M234
Slide Assembly



EX 433
Molded Slide
Assembly



PWB Ass'y



EX 433 Proximity Fuze

- ◆ **Required HOB Performance Envelope Demonstrated**
 - Passed Lab Simulated ERGM Environments
- ◆ **Navy Technical Data Package Developed**
 - Currently Being Updated



Reduced Power Active EM Fuze Underwater Torpedo Demonstration

Proof-of-Principle

- 85% Reduction of Input Power predicted by modeling
- Multiple Transmitter Designs
- Suitability of EM Fuzing for Small Diameter torpedoes



EM Fuzed Torpedo Shell Section

Successful Torpedo Sea Run Tests Conducted 7/01

- 6 out of 6 Target Detections
- Dynamic data (in water) indicates 66% power reductions
 - Non optimized hardware



Demonstration Results Brief
scheduled during Session V-B,

MEMS-Based F/S&A Technology Development & Application at IHDIV

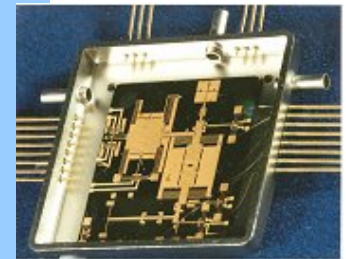
OBJECTIVES:

- ◆ Apply Demonstrated MEMS Based F/S&A Technology to Undersea Weapon Systems
- ◆ Develop and Integrate MEMS and Energetics Technologies for Low Cost F/S&A Systems & Applications i.e. Sub Munitions, Self Destruct etc.



APPROACH:

- ◆ Leverage ONR/DARPA MEMS Infrastructure Investments:
 - MEMS Design, Analysis, & Packaging
 - MEMS Explosives Cleanroom and equipment
- ◆ Capitalize on the MEMS Industrial Base
 - Commercial (COTS) Sensors & Devices
 - Commercial Foundries for S&A Chip Fabrication
- ◆ Demonstrate MEMS F/S&A Safety and Reliability
 - Assure Weapon Safety with Miniaturized Modular Architecture



MEMS F/S&A Indian Head Collaborations

Current Partnerships:

- **JDS Uniphase:**
 - MEMS and slapper foundry processing
- **Honeywell F&MT**
 - Miniature Fireset and Optical Interrupt
- **Applied Physics Lab – JHU**
 - Packaging and processing
- **University of Maryland**
 - Optics and packaging R&D
- **Tanner Laboratories**
 - Energetics and MEMS Development
 - CRADA established
- **Applied Research Lab @ Penn State**
 - Integration of MEMS S&A into CCAT



High Voltage Fireset



Slapper (Bridge) Detonator

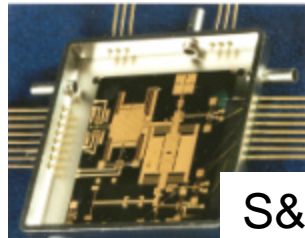


MEMS F/S&A Technology at Indian Head

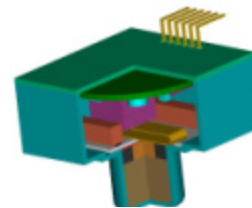
- MEMS Simulation Based Design Capability
- Micro-systems Packaging: chip-to-chip, explosive and electronics packaging & integration
- High voltage slapper based initiator development
- MEMS-Explosive Certified Cleanroom
- Conducted MEMS Reliability, Safety and Field Test
- MEMS S&A Staff with 40+ years MEMS S&A development experience
- On-going assessments of Industry Sensors & Micro-systems



S&A Chip



S&A Chip
Package



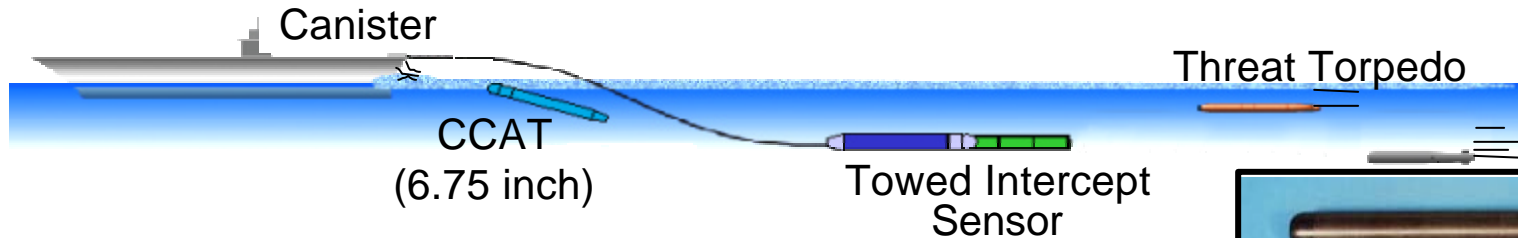
Slapper / Fireset
Package



CCAT S&A

NAVY MEMS-Based F/S&A Technology Program

Canistered Countermeasure Anti-Torpedo (CCAT)



MEMS S&A
for CCAT
Brief,
Session V-B



Status and Accomplishments

- CCAT MEMS S&A Prototype Development for Transition into CCAT E&MD
- MEMS S&A Technology Successfully Demonstrated in Aug 00 Sea-run Tests
- Baselined Overall S&A Components: Chip, Packaging, Initiation System, Sensor

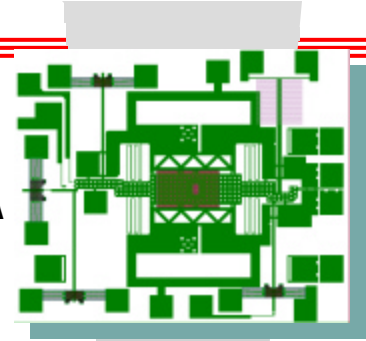
Examples of Maturing MEMS S&A Technology

Successfully transitioned from LIGA to DRIE as process for CCAT S&A

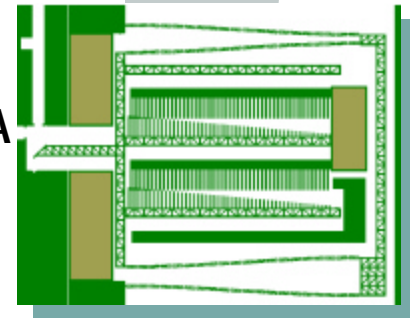
Accomplishments:

- Demonstrated : high displacement actuators and sliders, g-sensor, hydrostat, interrupter locks
 - Demonstrated S&A chips for energy interruption and firing energy transfer
- ⇒ Environmental, reliability, and field (sea-run) tested

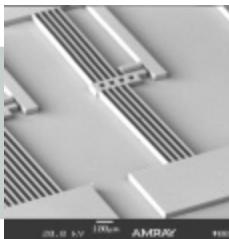
LIGA S&A Chip



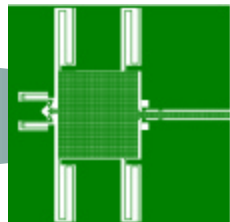
DRIE S&A Chip



DRIE Components



Thermal Actuator



G-Sensor

CCAT S&A

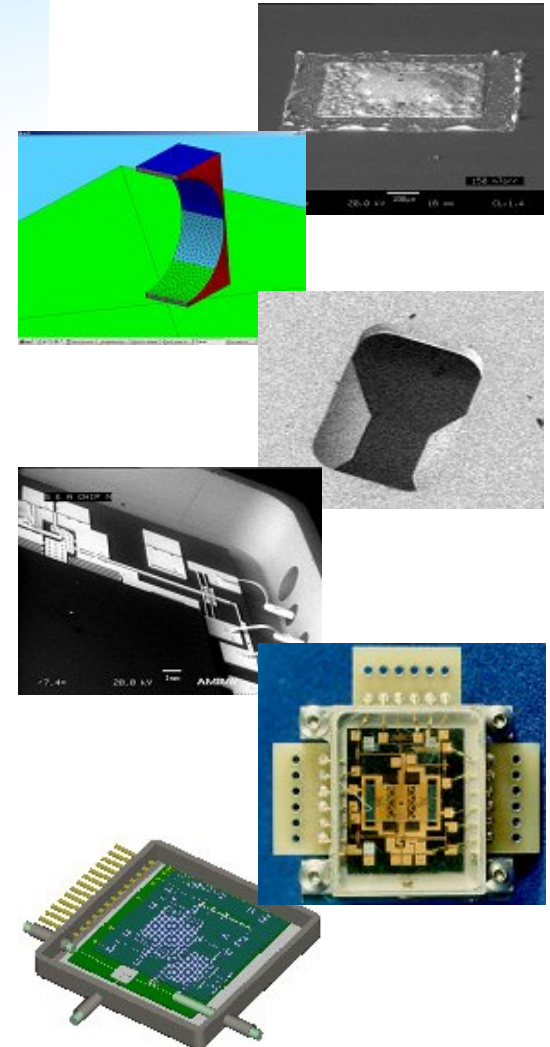


MEMS S&A Packaging

Provide robust packaging to meet shelf life and harsh environment requirements

Accomplishments

- Packaged MEMS S&A crucial for testing and demonstration
- Demonstrated MEMS S&A seal and bonding technologies
 - accelerated aging
 - thermal cycling



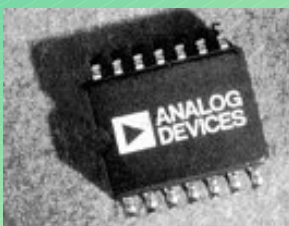
Typical Building Block Components for MEMS-Based Exploder



**Inertial Measurement
Rate Sensor**



**Flow Sensor:
Pressure Differential**



Impact Sensor



MTO

MEMS

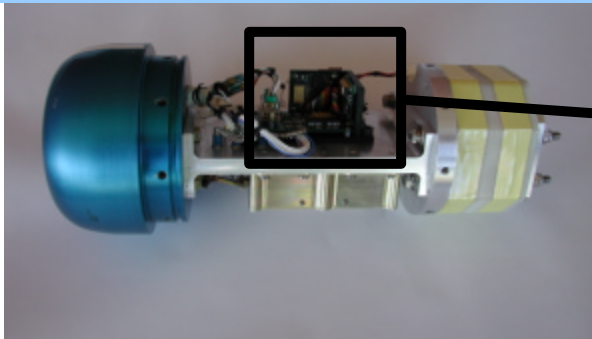
Undersea Fuze/Safety & Arming IMU for Close-In Ship Defensive

OBJECTIVE:

- ◆ Adapt a low cost, small volume Inertial Measurement Unit (IMU) for use in torpedo S&A devices

STATUS:

- ◆ Sea tests completed for using commercial IMU
- ◆ Conducted laboratory evaluation of numerous commercial IMUs
- ◆ Evaluated prototype with integrated commercial inertial sensor for torpedo application
 - ◆ Evaluation included launch (air gun) simulations & land simulations of torpedo runs



IMU for
CCAT Brief,
Session V-B

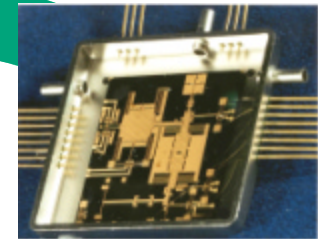
MEMS Fuze/S&A Technology Spin-Off Applications



**Flow Sensor:
Pressure Differential**



MEMS Fuze/S&A



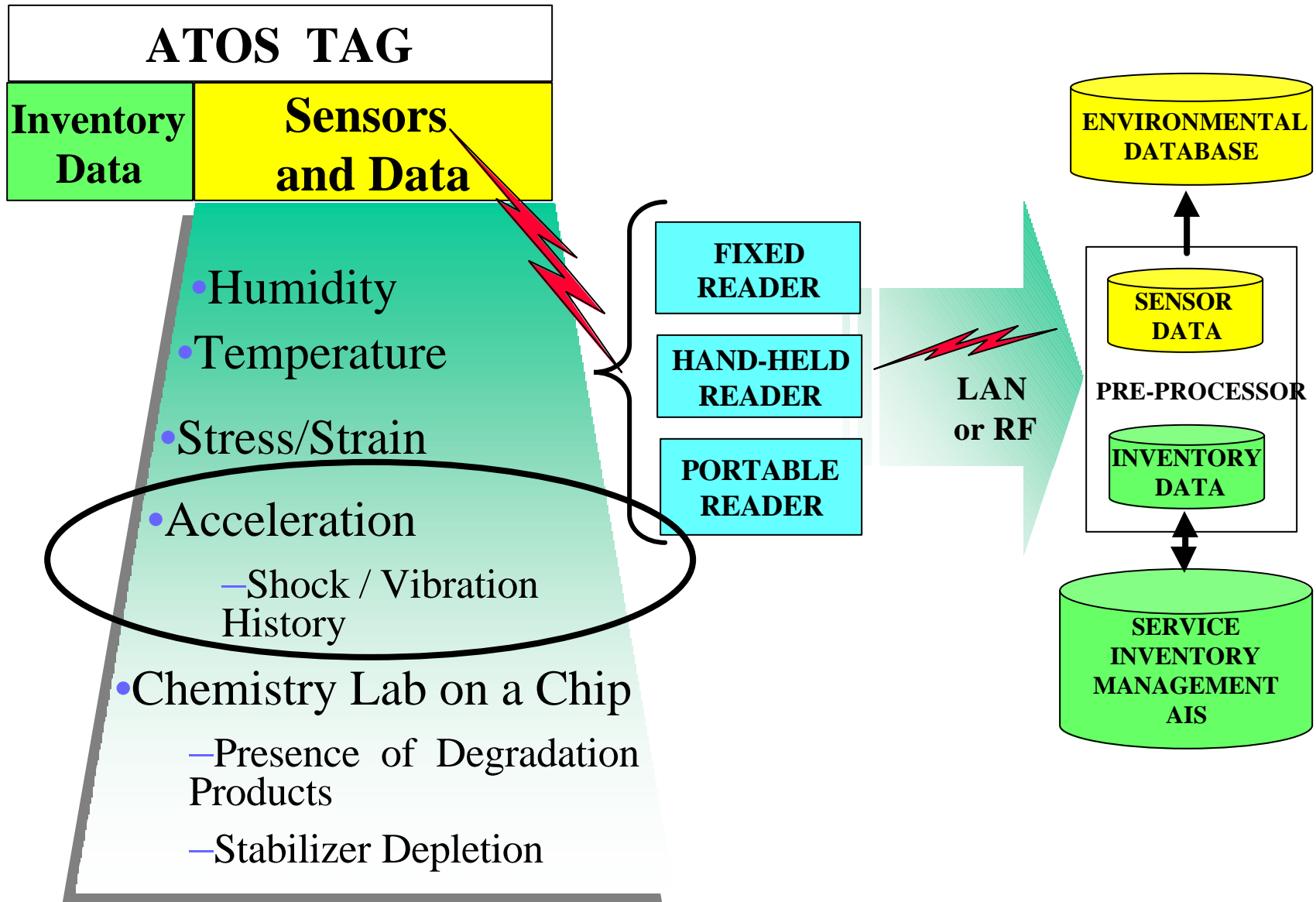
**S&A Chip
Devices**

Advanced Technology Ordnance Surveillance (ATOS)

- Advanced Concept Technology Demonstration – FY 01 - 03
- Demonstrate operational utility of miniature radio frequency identification (RFID) tags coupled with micro-electromechanical sensor (MEMs) technology for use in tracking/monitoring critical items:



ATOS RFID System



ATOS-RFID System

Integrated MEMS G-Sensor(s)

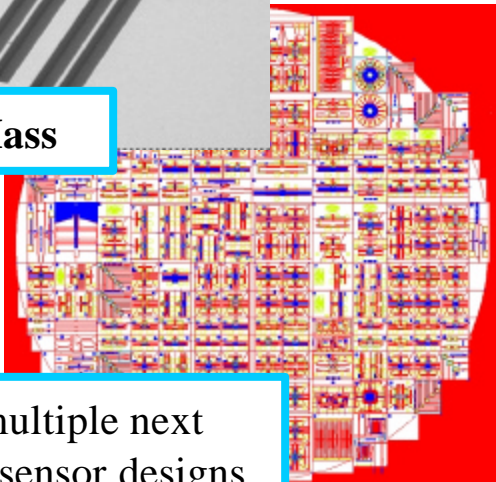
- **Spring supported mass deflects into latch when G-Sensor undergoes a defined shock**
- **ATOS-RFID records shock event when G-Sensor latch closes switch**

Status of Sensor Development

- **Three design iterations completed to date**
- **Baseline design successfully demonstrated**
- **Next generation designs being fabricated**
 - **Sensor types – 1, 2, 4 directions, multi-directional & multi-level**
 - **G levels – 50 to 3000**
 - **Additional features – manual & electrical unlocking**



Latched Mass

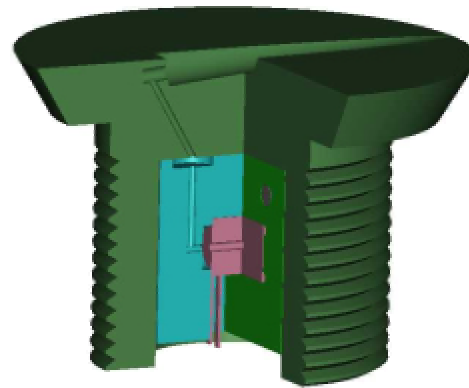


Wafer with multiple next generation g-sensor designs

Differential Pressure Flow Sensor Application and Commercialization

- **Water and Air Flow Measurement**
- Sensitivity demonstrated over 3 orders of magnitude of Re
- Licensed for marine, aeronautical, and automobile fields of use (Wickford Technologies)
- Completed commercialization Cooperative R&D effort
- Reduced to practical boating application in December 2001
- Conducted Sensor characterization testing in Tow Tank @ David Taylor Model Basin

Flow Sensor Packaged for
Marine Application <2 cu-in



Technology Investment

Micro Detonics

OBJECTIVE :

- ◆ Develop the enabling explosive material & manufacturing technology to produce low-cost, reliable on chip MEMS detonator

APPROACH :

- ◆ Investigate the use of thin film explosives that are formed *in situ* on silicon substrate (patent pending)
- ◆ Leverage MEMS industry manufacturing technology to develop batch process for high volume, low cost application

Indian Head NSWC MEMS Clean Room

Navy unique facility for Integrating MEMS, Electronics and Explosives

- Officially opened 29 Aug, 2001
- Class 10000 Cleanroom
- Explosive and MEMS Assembly
- Characterization
- Testing
- 800 Sq. Ft inert processing space expansion to begin late in 02
- Planned Capital investment for Detonic Technology Development

